REMARKS

This is in response to the Office Action dated August 17, 2010. Claims 4-34 are pending and stand rejected in the outstanding Office Action.

The rejection of claim 4 under 35 U.S.C. § 103(a), as allegedly being unpatentable over Kawasaki et al. (US 2003/0047785) in view of Goodman (US 4,204,217) and further in view of Yan et al. (US 2003/0218222), Vijayakumar et al. (US 4,751,149) and Wager et al. (US 2003/0218222), is respectfully traversed.

The cited prior art does not teach or suggest an active layer including intentionally added nitrogen and hydrogen dopants having concentrations so that a threshold voltage of a gate voltage of the semiconductor device is controlled to be substantially in a range between 0V and 3V

Regarding claims 4-5, the Examiner admitted that Kawasaki/Goodman/Yan does not disclose "said active layer includes said nitrogen and hydrogen as intentionally added dopants having concentrations so that a threshold voltage of a gate voltage of the semiconductor device, when a voltage between a drain and a source region is fixed at 10V, is controlled to be substantially in a range between 0V and 3V" (claim 4) and that "forming the active layer under an atmosphere containing…(ii) hydrogen peroxide"" (claim 5).

The Examiner cited Vijayakumar for teaching that hydrogen peroxide can be used as suitable oxidant for providing hydrogen as dopant, therefore, "it would have been obvious…that the ZnO active layer disclosed by Kawasaki/Goodman/Yan may be formed under an atmosphere containing hydrogen peroxide, because oxygen and hydrogen peroxide can be used interchangeably in forming a ZnO thin film to improve characteristics of the ZnO thin film. In this case, hydrogen would be an intentionally added dopant", see p. 5 of the Office Action.

Moreover, the Examiner cited Wager (e.g., paragraph [0049]) for allegedly teaching "a threshold voltage of a gate voltage of the semiconductor device, when a voltage between a drain and a source region is fixed at about 5 to about 40V, is controlled to be in a range between 1V and about 20V", and that it would have been obvious that the nitrogen and hydrogen may have concentrations so that a threshold voltage of a gate voltage is within the claimed range, "because a threshold voltage of a field effect transistor is an important device parameter that should be optimized no to apply a high bias voltage to the field effect transistor, which would increase power consumption, and a threshold voltage of a field effect transistor can be optimized by controlling an impurity concentration, a channel layer thickness, a gate insulating layer thickness, etc., to improve performance of the field effect transistor". Finally, the Examiner stated that "claim 4 is prima facie obvious without showing that the claimed range of the threshold voltage achieves unexpected results relative to the prior art range", see p. 6 of the Office Action.

Even though Vijayakumar teaches doping using hydrogen peroxide, <u>nowhere in Vijayakumar is there a teaching that the value of the threshold voltage is being controlled by the hydrogen dopants</u>.

Moreover, even though Wager teaches doping the ZnO layer with nitrogen, Wager teaches that this is done for "If doped, the <u>resistivity</u> of the ZnO may also be enhanced by substitutional doping with an acceptor dopant, such as, for example, N", emphasis added, [0038]. In other words, Wager does not teach that the doping concentration of nitrogen is chosen to control the threshold voltage, but rather he teaches that it is used to enhance the resistivity of the ZnO layer. As the Examiner admitted, there are other factors that can be used to control the threshold voltage, <u>so that it is not obvious to use the doping of nitrogen to control the threshold</u>

voltage. The threshold voltage range disclosed in Wager may result from any other factor, not from the concentration of nitrogen, let alone the concentration of hydrogen.

In addition, Applicant respectfully submits that the range for the threshold voltage of the gate voltage cited in claim 4 achieves unexpected results relative to prior art ranges, thus the cited prior art's teachings would not have made it obvious to intentionally add nitrogen and hydrogen dopants having concentrations so that a threshold voltage of a gate voltage of the semiconductor device is controlled to be substantially in a range between 0V and 3V, as alleged by the Examiner, see p. 6 of the Office Action.

Wager discloses properties of a TFT shown in Fig. 1, which has no protective layer.

A TFT having a protective layer has its threshold voltage shifted to an unpractical range, see p. 15, line 12 to p. 18, line 16 and Fig. 15 of the instant specification. The invention of claim 4 addresses this problem by employing an arrangement in which nitrogen and hydrogen are so doped that a threshold voltage of the TFT is in a practically usable range of 0V to 3V.

In a TFT having a protective layer, an interface level of a ZnO layer in back channel can be reduced. In contrast, in a TFT having no protective layer, an interface level of a ZnO layer in back channel (defect level of a ZnO layer on back channel surface) is so increased that band-bending in back channel is caused, resulting in the number of carriers (free electrons) being reduced. In the TFT having no protective layer, the band-bending is back channel causes band-bending in channel, and this causes a polarity of channel to be i-type. Thus, a threshold voltage of the TFT is in a practical range (2V to 5V).

On the other hand, in the TFT having the protective layer, the interface level of a ZnO layer in back channel is so reduced that no band-bending in the ZnO layer is caused. Therefore, ZnO can exist in an original state, i.e., a state in which free electrons generated from oxygen

deficiencies are large in number. As such, a polarity of channel is n-type. The increased number of the free electrons has to be removed in order that the TFT is turned off. As shown in Fig. 16 of the instant specification, such increase of the carriers which causes the threshold voltage of the TFT to be a large negative voltage is explained by the arrangement in which the resistivity is shifted and largely reduced by providing a protective layer in the TFT.

In the invention of claim 4, nitrogen and hydrogen are so doped that the number of the free electrons as carriers is reduced. This makes it possible to obtain a threshold voltage of the TFT in a practical range of 0V to 3V, <u>which is away from the expected range of large negative values (around -30V)</u>.

For the above reasons, claim 4 is allowable.

It is respectfully requested that the rejection of claims 5-34, each one dependent from claim 4, also be withdrawn.

In view of the foregoing and other considerations, all claims are deemed in condition for allowance. A formal indication of allowability is earnestly solicited.

The Commissioner is authorized to charge the undersigned's deposit account #14-1140 in whatever amount is necessary for entry of these papers and the continued pendency of the captioned application.

Should the Examiner feel that an interview with the undersigned would facilitate allowance of this application, the Examiner is encouraged to contact the undersigned.

Respectfully submitted,

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